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Correlative Study Between Harmonics of Daily Variation of Cosmic Rays and Solar Terrestrial Parameters

R. K. TIWARI*, BRIJESH K. MISHRA and AJAY K. PANDEY

*Department of Physics,
Govt. New Science College, Rewa, M.P., INDIA.

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ABSTRACT

We have done a systematic correlative analysis covering solar cycle 22 and 23 by taking the annual averages of amplitudes and phase of the first three harmonics of daily variation of cosmic rays (diurnal, semi-diurnal and tri-diurnal variation) for Kiel station against sunspot numbers, solar wind velocity and geomagnetic index ap. The harmonic analysis is carried out with the help of a computer program. We have used solar and interplanetary data mainly high speed solar wind velocity V, sun spot number Rz and geomagnetic index Ap. The results are discussed to explain the connection of cosmic ray modulation with solar and interplanetary features.

Keywords: Solar wind, solar cycle, cosmic ray modulation, geomagnetic indices.

INTRODUCTION

The long-term cosmic ray intensity variation in relation with solar activity has been studied since long time. Various solar indices such as sun spot number, grouped solar flares, coronal hole area, coronal mass ejection and solar radio flux have been used to explain the characteristics of long-term cosmic ray modulation. Sabbah *et al*. (2000), Tiwari *et al*. (2007), Venkatesan D. *et al*. (1990). Short term changes in the variation of cosmic ray intensity were reported by a number of researchers (Agrawal *et al.*, 1973; Kane, 2003;).

It is well established from the diffusion-convection theory that cosmic rays intensity varies with variation in solar wind velocity and a number of studies have been done to derive relation between them (Shrivastava *et al*., 1994; Ahluwalia, 1991, Rangrajan *et al*. 2000).

The geomagnetic field is usually disturbed when the magnetized solar plasma with specific characteristics flows through the vicinity of Earth. Ap, an index based on

linear scale, has been found a good proxy for the interplanetary disturbances, which should also be reflected in the daily variation of cosmic rays as well as long-term cosmic rays variation. Here, we presented a correlative study between daily variation of CR intensity and geomagnetic activity index Ap.

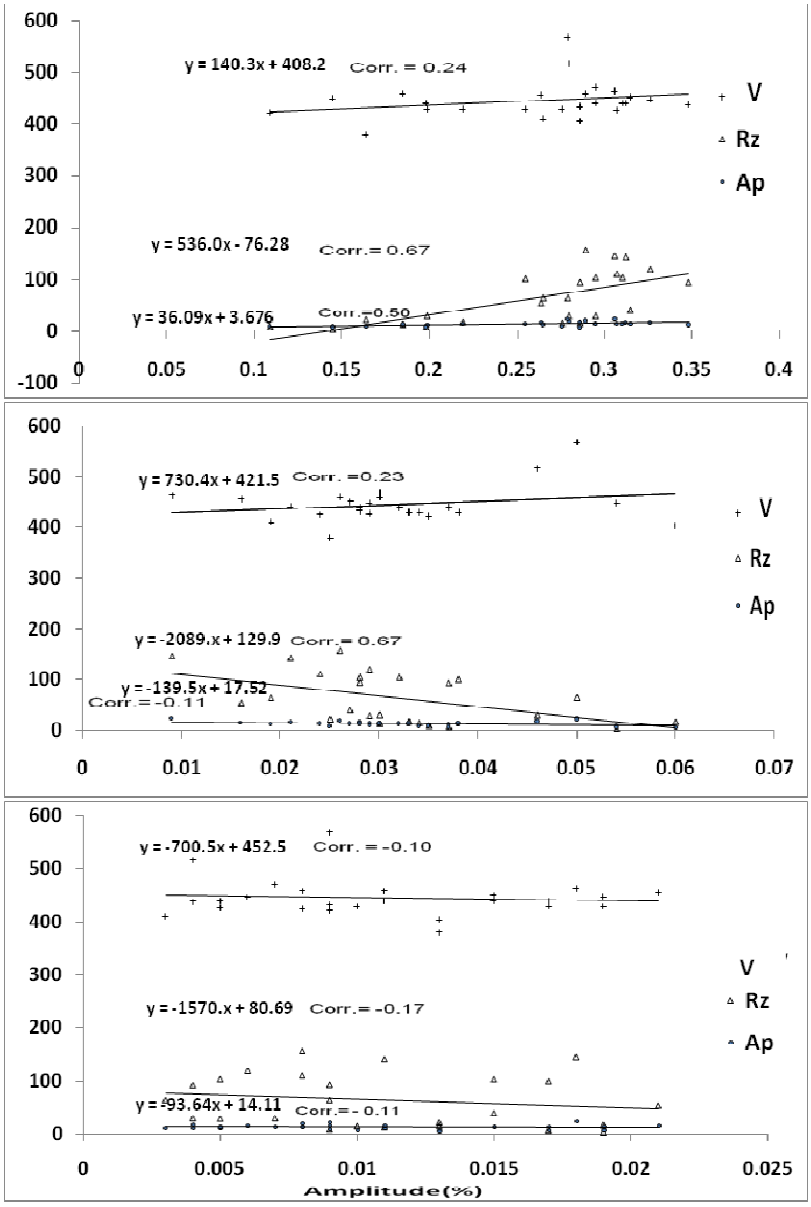

Figure 1 : Correlation plot between the amplitudes of harmonics of daily variation and V, Rz and Ap

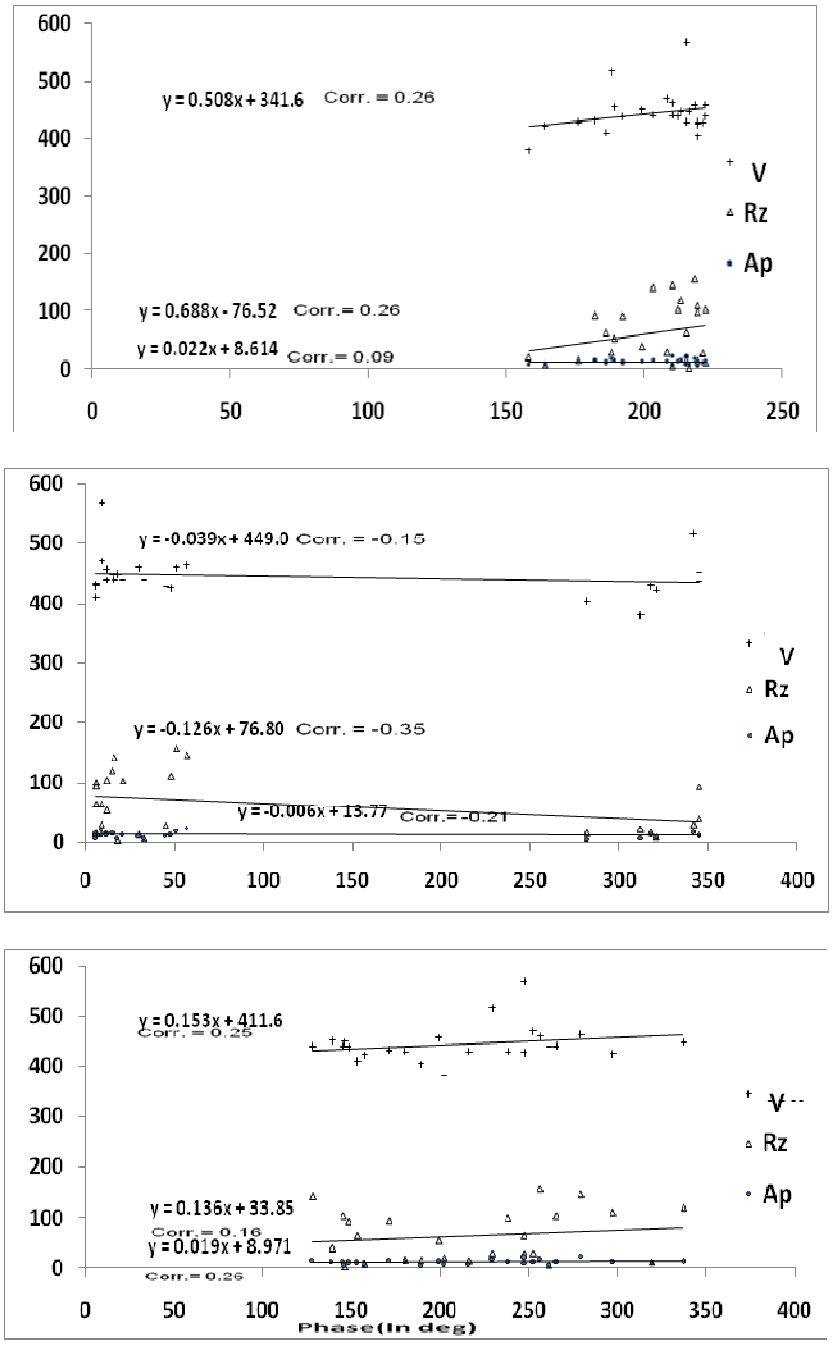

Figure 2 : Correlation plot between the phases of harmonics of daily variation and V, Rz and Ap

DATA AND METHOD OF ANALYSIS

It is well known that cosmic ray intensities are modulated by solar activity cycles. For this, we have used the pressure and temperature corrected hourly counts of Kiel neutron monitor station for the period 1986 to 2010, which cover the solar cycle 22 and 23 and also ascending period of solar cycle- 24. We have received the data for Rz, Ap and V for the period of 1986-2010 from national Space Science Data Center. (NSSDC) and National Geophysical Data Center (NGDC). A computer program is being used to derived the amplitudes and phases of the first three harmonics (since fourth and higher harmonics are not significant) of daily variation. Harmonic analysis technique has been adopted to derive the various characteristics of anisotropic (daily aviation) variation of cosmic ray intensity. The amplitudes and phases of daily variation components have been derived using this technique.

We have cross plotted the amplitudes and phases of first three harmonics covering solar cycle 22 and 23. of cosmic ray intensity and the value of V, Rz and Ap, as shown in the figure 1 and 2.

RESULTS AND DISCUSSION

We have correlated the first, second and third harmonics amplitudes and phases with sunspot number, solar wind velocity and Ap values. It is observed that the diurnal variation amplitude and phase both are positively correlated with V, Rz and Ap values. There is no significant correlation observed for the semidiurnal amplitude and phase with V, Rz and Ap values. The tri-diurnal amplitudes are poorly correlated and phases are positively correlated with the same parameters shown in the table 1.

Table. 1: The correlations coefficients for the harmonics of daily variation and solar terrestrial parameters

Harmonics	Amp			Phase		
	V	Rz	Ap	V	Rz	Ap
I	0.24	0.67	0.50	0.26	0.26	0.09
II	0.23	-0.49	-0.10	-0.15	-0.35	-0.21
III	-0.10	-0.17	-0.11	0.25	0.16	0.26

It is also observed that in a typical high/middle latitude neutron monitor station such as Kiel, the diurnal amplitude is substantially high during the maximum phase of the sunspot cycle, whereas the diurnal amplitude is quite small during decreasing phase and more so in the minimum phase of the sunspot cycle. Low Ap values indicate the quite interplanetary medium as well as low solar wind speed. The semi-diurnal amplitude and phase have not changed very significantly except in later periods associated with high values of solar wind velocity or Ap index.

The long-term variation of diurnal anisotropy at high energies plays a very crucial role in defining the interplanetary medium both in and out of ecliptic plane. Results of our analysis are also consistence with convection diffusion theory of cosmic ray modulation.

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